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agents. Those which lived to produce young gave rise exclusively to normal young, indicating that genetic changes were not responsible for the abnormal heads. However, in view of the known inheritance of eyelessness in cave arthropods and vertebrates and in *Drosophila melanogaster*, it seems of interest to examine each case of profound eye modification in crustaceans and elsewhere to gain information on the origin and inheritance of any possible mutation of this character.⁴

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CROSSING-OVER INVOLVING THREE SEX-LINKED GENES IN CHICKENS

IN the course of the last year several crosses of chickens carried out at the genetics station at Anikovo (near Moscow) have made it possible to observe crossing-over in this form. The genes "suke," "tuge" and "trage" were studied. The first, suke, retards the development of feathering in the chicks, so that at the age of 1 to 1.5 months they have very small tails. The development of the wings, too, is very slow. The genes trage and tuge together cause the well-known Plymouth Rock markings, trage causing the crossbarring, and tuge (not very visible in Plymouth Rocks, where it causes the contrasts in the markings) is the same gene as silver coloring, which was first reported by Hagedoorn in the Assendelver chickens. Later (1912) Davenport observed it in the cross of Dark Brahma \times Brown Leghorn, where, however, on account of the absence of several other genes, tuge has very little expression—only as a whitish edge on the feathers.

The genes suke, tuge and trage are all present together in the Plymouth Rocks. The Russian Orloff chickens have none of these genes, a condition which may be expressed as asuke-atuge-atrage. All these genes are sex-linked, and therefore are transmitted with complete linkage from mother to son. The cross

⁴Since this manuscript went to the printer two more eyeless *Moina macrocopa* were found in a crowded bottle. These two with the last one mentioned above were the only eyeless occurring among approximately 33,000 individuals microscopically examined (in sex-control experiments) during three months. The facts, that of these three two occurred in the same bottle and that the character is not inherited, again indicate clearly enough that external, not internal, factors are responsible.

Orloff male \times Plymouth Rock female gives cocks closely resembling the true Plymouth Rock, that is, crossbarred with slow feathering development. All the hens, however, are black (since in the Plymouth Rock there is also a gene for melanism, "tifa," which is not sex-linked), and they develop feathers quickly.

σ : asuke atuge atrage atife \times ϕ : suke tuge trage tifa

F_1 σ : suke tuge trage tifa ϕ : asuke atuge atrage tifa

In F_2 the coupling between suke, tuge and trage becomes broken, and different new combinations are to be observed in rather large numbers. More often the forms asuke-tuge-trage are obtained, colored like Plymouth Rock, but with quick development of feathering (among these there are also cocks), and conversely suke-atuge-atrage, with slow feathering, but black (when tifa is present). In one case a suke-tuge-atrage chick appeared, with slow feathering and silvery, but not crossbarred.

In the light of the Morgan theory these facts can be explained by regarding the genes suke, tuge and trage as being in a sex chromosome which cannot give crossing-over in the heterozygous sex (female). But when the same chromosome is transmitted to the F_1 male, it undergoes crossing-over with its partner, which occurs most often in the space between suke on the one side and tuge-trage on the other. Crossing-over between suke-tuge on the one side and trage on the other occurs less often, wherefore the arrangement of the genes in the F_1 may be represented as follows:

suke.....tuge.....trage

However, the counts of chicks which have so far been obtained in F_2 are not yet large enough to ascertain definitely the order of the genes, and therefore still less the exact distances.

A. S. SEREBROVSKY

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[Crossing-over between "suke" (barring) and "tuge" (silvery) has also been announced by Goodale (1917) and by Haldane (1921), in the papers listed below, which were not available to the above author.

Goodale, H. D. 1917. Crossing-over in the Sex Chromosome of the Male Fowl. *Science*, N. S., Vol. 46, p. 213.

Haldane, J. B. S. 1921. Linkage in Poultry. *Science*, N. S., Vol. 54, p. 663.

Note of Transmitter, H. J. Muller.]